Tweeting and Tornadoes

Justine I. Blanford
GeoVISTA Center
Pennsylvania State University
jib18@psu.edu

Jase Bernhardt
Geography Dept
Pennsylvania State University
jeb5249@psu.edu

Alexander Savelyev
GeoVISTA Center
Pennsylvania State University
azs5362@psu.edu

Gabrielle Wong-Parodi
Dept of Engineering and Public Policy
Carnegie-Mellon University
gwparodi@gmail.com

Andrew M. Carleton
Geography Dept
Pennsylvania State University
amc7@psu.edu

David W. Titley
Center for Solutions to Weather and Climate
Risk, Pennsylvania State University
dwt12@psu.edu

Alan M. MacEachren
GeoVISTA Center
Pennsylvania State University
maceachren@psu.edu

ABSTRACT

Social Media and micro-blogging is being used during crisis events to provide live up-to-date information as events evolve (before, during and after). Messages are posted by citizens or public officials. To understand the effectiveness of these messages, we examined the content of geo-located Twitter messages ("tweets") sent during the Moore, Oklahoma tornado of May 20th, 2013 (+/-1day) to explore the spatial and temporal relationships of real-time reactions of the general public. We found a clear transition of topics during each stage of the tornado event. Twitter was useful for posting and retrieving updates, reconstructing the sequence of events as well as capturing people's reactions leading up to, during and after the tornado. A long-term goal for the research reported here is to provide insights to forecasters and emergency response personnel concerning the impact of warnings and other advisory messages.

Keywords

Twitter, Tornado, Situational Awareness, Emergency Response, Message Warnings and Alerts, Risk Communication, Spatial and Temporal Visualization, GIS

INTRODUCTION

"*The best weather and water forecast can only save lives if it is communicated effectively to at-risk residents and the public officials who are charged with protecting them.*" Pg 37 (Sullivan and Uccellini, 2013). Communicating imminent risk from a severe weather event has the potential to reduce loss of life. Sullivan and Uccellini (2013), in interviews with media, emergency managers and staff at the National Oceanic and Atmospheric Administration (NOAA) and the U.S. National Weather Service (NWS), found that social media is playing an important role in communicating threats from weather events. For example, during Hurricane/Superstorm Sandy the Facebook pages and Twitter feeds of local government offices picked up several thousand followers who were looking for up-to-date information (Sullivan and Uccellini, 2013). In 2011, the NWS embarked on the 'Weather Ready Nation' initiative, to better fulfill its mission of protecting lives and livelihoods. Although much emphasis is being placed on technical capabilities that would enable the NWS to increase its warnings timeliness and accuracy, there is also a component of Weather Ready Nation that emphasizes the need to improve its effectiveness in communicating warnings and providing up-to-date information on high-impact weather events (NWS, 2013).

The power to communicate event information through social media has clearly been demonstrated (e.g., (Starbird and Palen, 2010b; Starbird and Palen, 2010a; Roche, Propeck -Zimmermann and Mericskay, 2011; Bruns, Burgess, Crawford and Shaw, 2012; Sullivan and Uccellini, 2013)). Social media has been useful in the circulation and dissemination of news (Kwak, 2010), as well as in providing live up-to-date information on a variety of environmental hazard events through citizen reporting (e.g., earthquakes in the USA (Crooks, Croitoru, Stefanidis and Radzikowski, 2013) and Haiti (Roche et al., 2011); flooding on the Red River in the USA and Canada (Starbird, Palen, Hughes and Vieweg, 2010; Vieweg, Hughes, Starbird and Palen, 2010); and wildfires in USA (Vieweg et al., 2010)). With the increasing ability to utilize geographic information, either through mining the content of a message or via its geographic properties, it is now much easier to analyze information spatially. For example, SensePlace2 (MacEachren, Jaiswal, Robinson, Pezanowski, Savelyev, Mitra, Zhangi and Blanford, 2011) can integrate geospatial, temporal, and attribute dimensions of Twitter, providing inputs to situational awareness and an understanding of reactions to events (e.g., (Robinson, Savelyev, Pezanowski and MacEachren, 2013)).

For the public to take action, warnings must be understood by the recipient before they can be acted upon. Several factors may affect whether people fully process and understand the information contained in a warning including past experience with natural hazard events, general awareness, and belief and trust (see (Brotzge and Donner, 2013) and references within for details). To be successful, warnings must communicate the necessary information clearly in a timely manner to allow users to react (Brotzge and Donner, 2013). An important question that has had limited attention thus far is how to leverage social media as a lens through which to analyze citizen reactions to natural disasters associated official advisories and warnings. As a step toward addressing this question, we used Twitter to assess the effectiveness of warning messages sent during the Moore, Oklahoma tornado of May 20th, 2013 (+/-1day) by exploring the spatial and temporal relationship of real-time reactions of the general public as the storm system developed into a tornado.

Oklahoma Tornado: During late May, 2013, a series of tornado-producing storm systems swept through the greater Oklahoma City, OK region. A particularly violent tornado touched down at 14:56 hr (all times Central Daylight Time) near Newcastle, 16 minutes after a tornado warning was issued by the NWS Norman, Oklahoma office. The tornado rapidly strengthened, tracking directly over the city of Moore. The tornado travelled a total of 22.5 km in 39 minutes, with a maximum path width of 1.7 km (NOAA, 2013a), and attained a rating of EF-5 on the Enhanced Fujita Tornado Damage Scale, the maximum rating possible. Due to its strength, longevity, and passage over a populated area, the tornado claimed 24 lives and caused extensive damage (Kuligowski, Phan, Levitan and Jorgensen, 2013).

We analyzed 86,100 geo-located tweets collected between May 19th (the day prior to the tornado) and May 21st (the day after the tornado) 2013, for Oklahoma. Tweets were captured using the Twitter Streaming API version 1.1 (https://dev.twitter.com/docs/streaming-apis/streams/public) and saved to a text file in JSON format using a node.js application (http://nodejs.org/).

Tweets containing tornado-relevant information were identified by querying for keywords that included: 'tornado' (+watch, +warning), 'storm', 'weather', 'take/ing cover', 'shelter', 'pray', 'emergency', 'red cross', 'help' and the root of 'devast' (to include devastated and devastation), 'destruct' (to include destructed and destruction), and 'donat' (to include donation(s) and donate). A set of keywords were selected through an iterative process to capture relevant tweets related to the tornado event. We started with words related to tornadoes and then included additional keywords to capture tweets about the tornado before and after the event.

Figure 1 depicts the spatial temporal distribution of tweets with any of the specified keywords. People were clearly interested in the weather, storms and tornadoes. Not surprisingly, on the day of the tornado the number of tweets containing the word tornado increased. During and after the storm the number of tweets including prayers increased as did those relating to destruction, devastation and requests for help and donations.

We next explored the spatial and temporal distribution of tweets on May 20th in more detail using ArcMap 10.2. Figure 1 shows the spatial distribution of tweets by keyword prior to the tornado touching down (i.e. tweets captured before 14hr), during the tornado (14hr – 16hr) and post-tornado (after 16hr). Pre-tornado tweets are primarily composed of those containing keywords that highlight impending threat, such as storm, tornado, and watches / warnings for severe weather and tornadoes. During the tornado itself, the keywords are focused increasingly on the dynamic response to the event, namely deployment of the emergency alert system (sirens), and the resultant precautions taken by individuals in response (shelters). Finally, after the tornado dissipated, the main keywords highlight the destruction and damage that occurred. Figure 2 shows that the frequency of tweets also increases, peaking during the tornado touchdown. After the tornado touched down, the number of tweets containing the word tornado decreased, but much more slowly than it peaked.

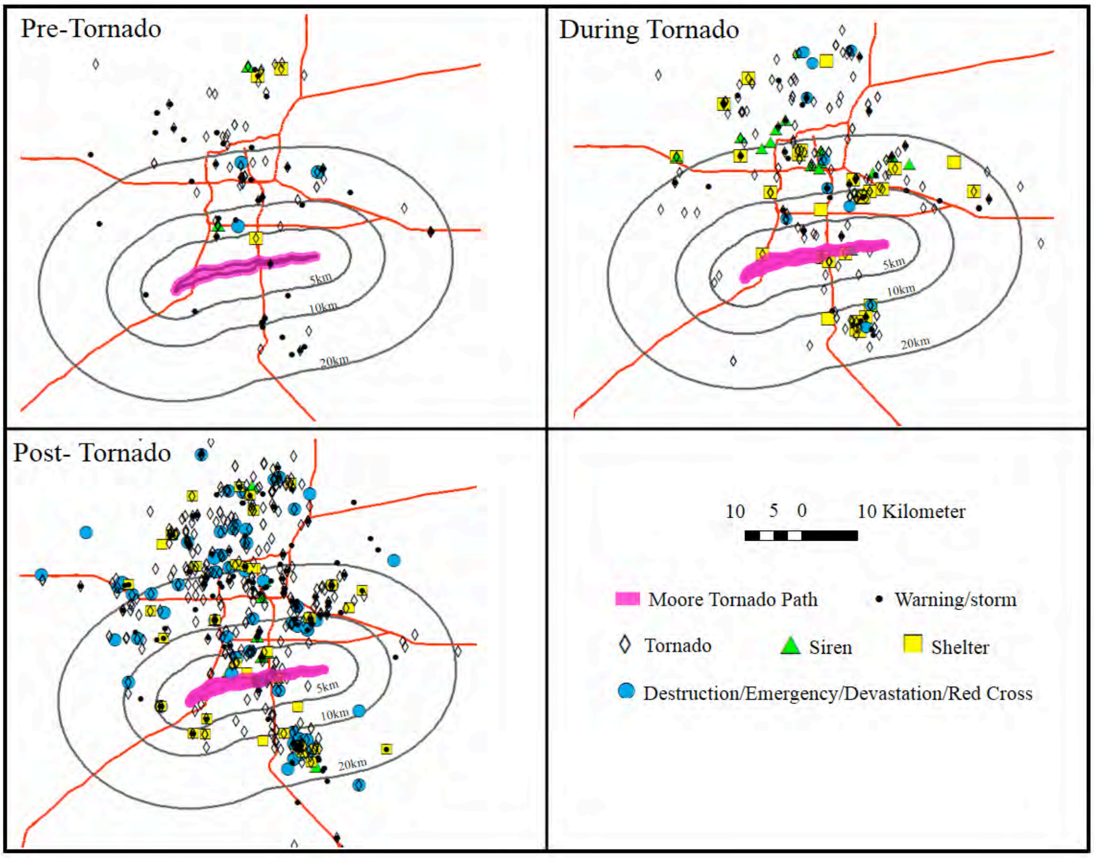
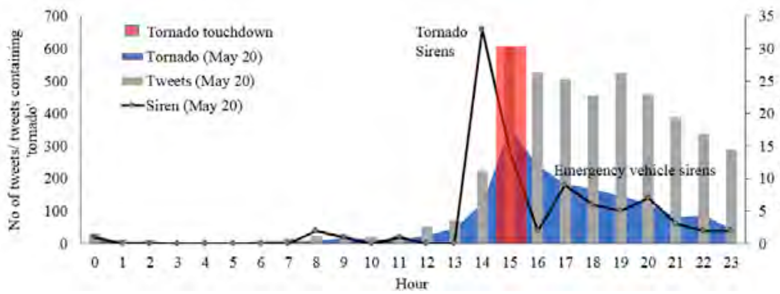


Figure 1: Maps of distribution of tweets with keywords pre, during and post tornado touchdown, May 20th. Tweets within 5, 10 and 20km of the tornado path fall within the concentric buffer zones (grey lines). Tweets outside of this area are greater than 20km from the tornado path.

Between 5:00hr and 15:37hr on May 20th, the NWS office in Norman, OK issued a series of severe weather watches and warnings. These statements were officially disseminated by the National Weather Service through various media, including Twitter (see (NOAA, 2013b)). A total of 36 tweets were posted by NWS, resulting in 2,583 retweets) (see Figure 3). Similar to the tweets illustrated in Figure 2, tweets about the tornado remained low through the day, dramatically increasing in the hour preceding the Moore tornado. Interestingly, of all the retweeted messages, the message requesting users to retweet had the highest retweet (19%). Fifty-eight percent of the retweets occurred during the tornado warning, 33% of these were for messages telling people to take action such as 'take cover'; 18% were for updates on the tornado's movement and location, while the remaining messages highlighted tornado preparedness and what not to do (e.g., be in your car).

Figure 2: Temporal distribution of tweets with at least one keyword (gray bars) (e.g., 'storm', 'weather', 'take/ing cover', 'shelter', 'pray', 'emergency', 'red cross', 'help' and 'devast', 'destruct', and 'donat' in relation to tweets containing the keyword 'tornado' (blue area) or 'siren' (black line) and how these related to the tornado event (red bar). Tweets were summarized for each hour.



Sirens in Moore were sounded six times with the initial siren occurring shortly after the first NWS tornado warning was sent (14:41hr) with the final warning at 15:20hr (Kuligowski et al., 2013). The first mention of sirens also begins at 14:41hr (N=22 tweets in 4 minutes) with tweets such as "*Sirens going off now!! Take cover...be safe!*", *"Sirens sirens sirens. Becoming so real",* and "*If u hear a tornado siren, uve got 6-8 minutes…"*

An initial tornado warning was issued for the Moore tornado at 14:40hr, valid through to 15:15hr, based on the projected tornado track. A total of 104 tweets were sent from inside the warning zone. Within 3-7 minutes of the tornado warning being issued, 4 tweets mentioned tornado sirens; 3 of which referenced the sounding of a tornado warning and 27 contained the word 'tornado'. The content of the tweets varied with users providing technical details (re-tweets of storm spotter reports) to the brief ("*Dang this tornado is huge*") and more descriptive "*Saw two, looks like more tornados forming. Taking shelter now."* It was clear that people continued tweeting to provide situation updates, but also expressing their frustrations and sentiments (e.g., *"Why are there no public underground tornado shelters in every OK town?! THIS IS TORNADO ALLEY! @MaryFallin @OKSENATEINFO @OKHouseofReps.")*.

Figure 3: Timeline of warning messages sent by NWS Norman on May 20th with the number of retweets for each message (black bars), sirens (dark yellow), time of tornado touchdown (blue) and the time and duration of the tornado warning (red area).

Content analysis of the tweets found that tweets were used to provide situational updates such as relaying media reports, which included television stations KOCO, KJRH, and KFOR, the University of Oklahoma emergency alert system, and re-tweets of information from the NWS (*e.g.,"KOCO is talking about the south, guys. Wall cloud. No tornado yet."*); providing real-time weather observations (*e.g., "This tornado is about a mile wide. Oh dang."*); providing the location of shelters (*e.g., "If you're on campus, seek shelter in Residence Hall basements, Union basement or Huff. #OU #okwx"*); and communicating personal safety and locating family and friends *(e.g., "We are ok. F4 tornado hit about 2 miles from us. Don't have power right now. Hope this posts."*). After the tornado passed, messages included situational awareness and damage reports (e.g., *"Heavy tornado damage near SE 4th and Bryant. Homes are gone"* and *"Children trapped in #Moore guess ill be #volunteering all night #oklahomatornadoes #oklahoma #okiepride #help #tornado #redcross."*).

CONCLUSION

Twitter is an effective messaging system that enables information to be received and posted in a timely manner. During the Moore, Oklahoma tornado, Twitter was useful for providing updates and relaying of information. By analyzing the text of each tweet and using a list of keywords, we gained insights into what happened on the ground and understood people's interest and reactions, both spatially and temporally. For unpredictable and destructive/hazardous weather events, such as the tornado analyzed here, the time between issuing a warning and the tornado touchdown can be short, emphasizing the need for clear communication. Including a request to retweet may help facilitate the wider dissemination of critical information via Twitter. The study presented here highlights the need for additional research that should include strategies for prompting retweets, identify messaging that works and does not work and assess the role of volunteer communities in communicating risk obtained from a variety of both formal (e.g., NWS) and informal (e.g., TV stations, social networks, personal observations) sources of information. In this study we analyzed data for a single event. A long-term goal for the research reported here is to provide insights to forecasters and emergency response personnel concerning the impact of warnings and other advisory messages. To broaden the applicability for this kind of data, comparing events of different sizes and duration may provide a deeper understanding of people's responses during catastrophic weather events (Bagrow, Wang and Barabasi, 2011). Future work could also build on previous studies, such as Mendoza, Poblete and Castillo (2010) and analyze warning messages to help maximize the likelihood that the public will take the most appropriate action during an event. In addition, develop a lexicon of the most appropriate words and phrases to use to query the public's response will enable the quick retrieval of relevant tweets before, during and after an event.

REFERENCES

1. Bagrow, J. P., Wang, D. S. & Barabasi, A. L. (2011) Collective response of human populations to large-scale emergencies. *PLoS One,* **6,**
2. Brotzge, J. & Donner, W. (2013) The tornado warning process. A review of current research, challenges, and opportunities. *Bulletin of the American Meteorological Society,* **94,** 1715-1733
3. Bruns, A., Burgess, J., Crawford, K. & Shaw, F. (2012) #qldfloods and @qpsmedia: Crisis communication on Twitter in the 2011 south east Queensland floods pp. 58. ARC Centre of Excellence for Creative Industries and Innovation, Queensland, Australia.
4. Crooks, A., Croitoru, A., Stefanidis, A. & Radzikowski, J. (2013) #earthquake: Twitter as a distributed sensor system. *Transactions in GIS,* **17,** 124-147
5. Kuligowski, E. D., Phan, L. T., Levitan, M. L. & Jorgensen, D. P. (2013) NIST special publication 1164: Preliminary reconnaissance of the May 20, 2013, Newcastle-Moore tornado in Oklahoma. pp. 81. National Institute of Standards and Technology Special Publication
6. Kwak, H. (2010) What is Twitter, a social network or a news media? In: *The International World Wide Web Conference*, pp. 591-600. Raleigh, North Carolina.
7. MacEachren, A. M., Jaiswal, A., Robinson, A. C., Pezanowski, S., Savelyev, A., Mitra, P., Zhangi, X. & Blanford, J. (2011) Senseplace2: Geotwitter analytics support for situational awareness In: *IEEE Conference on Visual Analytics Science and Technology (VAST)*, pp. 181-190. Providence, RI
8. Mendoza, M., Poblete, B. & Castillo, C. (2010) Twitter under crisis: Can we trust what we RT? In: *1st workshop on Social Media Analytics (SOMA '10)*, pp. 9. Washington, DC.
9. NOAA (2013a) The tornado outbreak of May 20, 2013. pp. National Weather Service Weather Forecast Office, Norman, OK.
10. NOAA, N. (2013b) Information services chronology for the tornado outbreak of May 20, 2013. pp. NWS NOAA.
11. NWS (2013) Weather-ready nation roadmap v2.0. pp. 81. The US Weather Service, NOAA.
12. Robinson, A. C., Savelyev, A., Pezanowski, S. & MacEachren, A. M. (2013) Understanding the utility of geospatial information in social media. In: *10th International ISCRAM Conference* (Eds, Comes, T., Fiedrich, F., Fortier, S., Geldermann, J. and Muller, T.), pp. 5. ISCRAM, Baden-Baden, Germany.
13. Roche, S., Propeck -Zimmermann, E. & Mericskay, B. (2011) Geoweb and crisis management: Issues and perspectives of volunteered geographic information. *GeoJournal,* **78,** 21-40
14. Starbird, K. & Palen, L. (2010a) Tweak the tweet: Leveraging microblogging proliferation with a prescriptive grammar to support citizen reporting. In: *7th International ISCRAM Conference (Short Paper)*, pp., Seattle, WA.
15. Starbird, K. & Palen, L. (2010b) Pass it on?: Retweeting in mass emergency. In: *7th International ISCRAM Conference*, pp., Seattle, WA.
16. Starbird, K., Palen, L., Hughes, A. L. & Vieweg, S. (2010) Chatter on The Red: What hazards threat reveals about the social life of microblogged information. *2010 ACM Conference on Computer Supported Cooperative Work,* 241-250
17. Sullivan, K. D. & Uccellini, L. W. (2013) Service assessment: Hurricane/post -tropical cyclone Sandy, October 22 – 29, 2012. pp. 66. U.S. Department of Commerce NOAA and NWS, Silver Spring, Maryland.
18. Vieweg, S., Hughes, A. L., Starbird, K. & Palen, L. (2010) Microblogging during two natural hazards events: What Twitter may contribute to situational awareness. *CHI 2010: Proceedings of the 28th Annual CHI Conference on Human Factors in Computing Systems,* **1-4,** 1079-1088